

Student questions: Aldo Spadoni colloquium on “Exploring the Boundaries of Art, Design, Aerospace Engineering & Popular Culture”

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Question 1: What types of programs and/or art forms do you primarily utilize in your projects?

I use a variety of traditional artist tools and software to create my imagery. I usually start with simple pencil and paper to develop rough sketches and forms. If my deliverable requirements do not require photorealistic rendering, I will usually create final refined sketch concepts with pencil, pen and ink and magic markers. Frequently I will use Adobe Photoshop to manipulate and combine hand-created marker sketches that I scan into my computer. I create 3D models with various software applications such as Modo. My primary software tool for bringing all the elements together and creating finished artwork is Photoshop.

Question 2: What is your involvement in educational outreach and the promotion of STEAM?

I am currently mentoring a group of fourth grade special needs students through the IEEE TryEngineeringTogether eMentoring program. The program is exploring new methods for remotely accomplishing STEM/STEAM outreach. I’m one of the program guinea pigs! I also participate in various STEAM outreach activities through the International Association of Astronomical Artists (IAAA).

Question 1: You talked about how engineering can (and should!) influence science fiction design. Have you ever gone the other way and used science fiction design as a model for an engineering project?

I was asked to envision collaborative educational and work environments of the future. I really like the idea of somehow physically interacting with conceptual designs that are computer generated and projected holographically or by some other advanced method. I’m talking about something along the lines of Tony Stark’s personal laboratory as depicted in the Iron Man films. I used that idea as a basis for creating illustrations that were used for various future engineering workspace development initiatives. Hopefully we’ll get there someday.

Question 2: Do you find engineering or art to be more intellectually stimulating?

What I find most intellectually stimulating is combining both engineering and art together, rather than pursuing them individually.

Question 1: Have you ever found yourself up against an insurmountable obstacle in your design process – what was it?

Hmmm, interesting question. I would say I never confronted anything “insurmountable.” However, there are always obstacles that might yield a final design idea that is not as good as I know I could make it. Usually this is because there simply isn’t enough time to get it done, the project is cancelled, etc. But if your task is to conceive of an idea and visualize it rather than actually being required to build it, then I believe nothing is really insurmountable from the conceptual standpoint.

Question 2: Was any formal art training required for you to get to your current skill level or were you entirely self-taught?

I am mostly self-taught as an artist and illustrator. However, I did take some industrial design and rendering classes at the Art Center College of Design in Pasadena, California, which was a wonderful experience. Beyond that, it’s all about practice!

Question 1: In terms of the process of designing something, how does it differ between Hollywood purposes and science/engineering purposes?

As I described in my colloquium talk, the engineering world usually develops concepts to solve a particular problem or need. If you can quantitatively define the problem or need, you can then come up with a set of requirements and refine them as necessary. This drives the design process. In my experience, the world of Hollywood is far less rigorous in this regard and usually does not think in terms of quantitative requirements. Most movies simply determine what “assets” are needed in the film based on the script. If they’re lucky, they might have a written backstory or the movie may be based on a hard science fiction novel which they can use as a guide. Hollywood’s goal is usually to come up with something that looks cool as the primary design driver. However, some movie and television show productions do appear to spend more time thinking about vehicles as engineers would, at least to some extent. They may have technical advisers they actually listen to. I generally like the way spaceflight and related aerospace technologies are depicted in the recent SyFy Channel series, “The Expanse.”

Question 2: When do you know/decide that a design is done?

Great question! There’s an expression that applies here and that is “perfection is the enemy of good enough!” Artists are frequently guilty of overworking a piece. As an engineer, I know that I need to scope out a project beforehand so that I know how much time and budget I have to complete it. By understanding the total level of effort required, I get a feel for how much free-wheeling concept exploration I can do before I have to finalize the design. Knowing when it’s done comes from real world working experience.

Question 1: What advice would you have for someone headed into a STEM/STEAM career who has a more artistic approach to science?

I would use that artistic approach to your advantage! If you understand and have competence in the science and mathematics related to your field, and you also have the ability to create art, you have a significant advantage over those who are not able to work visually and communicate their visions. If you are less interested in the quantitative side of STEM, work with your science and technical counterparts to help them visualize their work.

Question 2: How do you think STEM educators can do a better job of incorporating art into science as a means to engage a larger audience and help increase scientific literacy?

STEAM is relatively new and not as recognizable as a counterpart to STEM. The first step is for STEM educators to recognize the importance of incorporating the Arts into their curriculum. There are some good online resources that advise on how to teach STEAM.

Question 1: What computer programs do you use to create your art?

I create 3D models with various software applications such as Modo. My primary software tool for bringing all the elements together and creating finished artwork is Adobe Photoshop.

Question 2: Would you recommend science fiction writers (both for books and movies) consult with a proper team of engineers to better design air/space craft so it's less fiction and more science?

Heck yeah!!! However, most writers don't have easy access to "a proper team of engineers." There are some excellent resources for writers online. There are a number of Space oriented Facebook groups that have a wealth of Aerospace knowledge and would be happy to help writers willing to learn. One of the best online resources is the Atomic Rockets website, operated by a great guy named Winchell Chung. This site was specifically created for science fiction authors who want to learn about spacecraft, spaceflight and all the related science, physics, engineering, etc. It's a really fun place to explore and highly recommended!

http://www.projectrho.com/public_html/rocket/

Question 1: Do you see a future where real world designs might be influenced by fiction rather than the reverse which is happening now?

I think real world designs have already been significantly influenced by science fiction over the years. Things like spacecraft, video phones, tablet computers, 3D printing, and many other ideas were initially described in science fiction books and/or shown in science fiction movies before they became reality. Of course, many of these ideas originated with the scientific and technical community as they brainstormed what might be possible in the future. Good science fiction writers research these possibilities in order to create their stories and movies, making them more accessible to a broad audience. So historically, there has always been a back-and-forth exchange of ideas between the worlds of fiction and reality.

Question 2: When doing concept art for a design do you feel it's necessary to make it “prettier” than it will likely turn out in order for it to gain traction?

I think that is project specific. Certainly, in the world of Hollywood and videogame production, they are usually far more interested in the look of a concept rather than its functionality. On the other hand, an aerospace engineering request for proposal will probably never include a requirement saying that “it’s gotta look cool!” However, there’s a saying among fighter pilots: “looks good, flies good!” A motivated and enthusiastic aerospace development team naturally wants to come up with something that not only meets the requirements but is visually compelling and spectacular as well. In my opinion as an experienced engineer/artist, I’d say that a well-executed design usually incorporates a certain aesthetic appeal.

Question 1: What would your dream project be?

Hmmm, let's see . . . I wouldn't mind having the title of Chief Engineering Visualization Futurist (CEVF) at a company like SpaceX, Blue Origin, etc. My task would be to envision the next thousand years of human spacefaring and expansion, with enough budget to hand-pick my own dream-team to perform detailed advanced engineering studies and create multiple feature length films and virtual reality experiences to communicate the vision. Yeah, I kinda like the sound of that :-) I will pretty much be doing this sort of thing anyway on my own, but without the title, resources and budget. ☺

Question 2: Did you have to create your own opportunities to integrate art into STEM and what advice would you give to someone trying to become more involved in STEAM?

I created my own opportunity by creating a group at Northrop Grumman called the Engineering Visualization Resource, that did not exist before within the company's organization structure. Not an easy thing to do in a large bureaucratic organization. If you are interested in becoming more involved in STEAM as an educator or as a practitioner, go out of your way to incorporate great visuals in your work and your presentations. Show your students or audience how using the visuals help you to better explain the concepts. Perhaps you could compare the visuals to a text-only description of the concept in order to make the point. If you can't create the visuals yourself, seek out and team with others who can.

Question 1: How long does drafting typically take?

“Drafting” is probably not the most appropriate word for anything that I do. Rendering artwork usually takes anywhere from, say, 4 to 40 hours, depending on the complexity of the illustration. Building a 3D model in CAD software is the modern-day equivalent to 2D drafting. That can also be very time consuming depending on the complexity of the design and how good of a CAD jockey you are!

Question 2: Is it easier to start from scratch or to have something to base your design on?

Inheriting someone’s project is usually not my preferred way to proceed. I’d much rather design from scratch. But realistically, a designer always takes a look at what has been done before, for a particular category of aerospace vehicle, and perhaps use that research as a point of departure to explore new designs.

Question 1: How do you think that art fits best into STEM? What does STEAM look like to you?

I think my presentation slides at least somewhat show how art and illustration fit into STEM. Notice I used barely any word slides and used pictures almost exclusively to convey ideas. And these pictures were mostly artistic creations and not photos, because the concepts I was conveying largely don’t exist as photos. That’s what it’s all about!

Question 2: What do you think is a more difficult career to succeed in: academic science or artistic production? Why?

It really depends on how you choose to define success. If you are talking about monetary success, where you are paid well enough to maintain your lifestyle choices, then a scientific/technical career is probably more likely to provide that kind of result. If you define success as achievement of personal goals and to be recognized as professionally competent by your peers, you can succeed in either pursuit. As to which one is more difficult in that case, it’s really up to the individual.

Question 1: Do you ever do any artistic concepts of galaxy formation?

Yes, I’ve done illustrations of various cosmological subjects including galaxy formation as part of various spacecraft programs I’ve worked on, such as the NASA Compton Gamma Ray Observatory (GRO), working with the NRAO, etc. Though, pure astronomical artwork is not my specialty.

Question 2: Are you working on any more video game concepts?

If I tell you, I’ll have to use the flashy thing to wipe your memory! ;-) Actually, I’m currently talking to a VR Game company about the possibility of working with them to create designs for a future space adventure. We’ll see if it goes anywhere.

Question 1: How much of your current job is traditional engineering and how much is art?

I would say that my projects are roughly 75% visualization and 25% engineering, depending on the particular project and what my customer is looking for. I usually don't do detailed engineering analysis because my customers typically already have engineers to do that. Usually, my work involves understanding what concepts the engineers have come up with, understanding the solution space for the problem at hand, and helping them develop top level ideas and visualizing the concepts.

Question 2: Are there any movies/books/video games that you would particularly like to work on?

I'm certainly a fan of hard science fiction literature and I would love to work on envisioning almost any of the great works of the genre! As I mentioned in my talk, I've worked extensively with science fiction writers such as Larry Niven, Jerry Pournelle, and others.

Question 1: Do you think that other forms of art, such as music, could be used as extensively with aerospace engineering as visual art?

That's an interesting question. I think it's obvious how visualization can enhance engineering projects. Offhand, I can't really think of an equivalent way that music would be used other than indirectly, such as making sure that music is available to human crews for long duration spaceflight to maintain psychological health. Perhaps music could be used in some way to convey information as a supplement to visual command and control systems? I'm certainly open to any idea if some engineering musicians or other non-visual artists could show us the way!

Question 2: Do you ever come up with your own stories around the ships you design?

I've always dreamed about writing hard science fiction short stories and perhaps a novel. I do have some story ideas I've been bouncing around in my head for years. I like to write but for me, it doesn't flow as naturally as visual artistic expression. Hey, it's on my long-range to-do list! ☺

Question 1: What was your favorite design?

I'm not a "favorites" kind of person, but if I had to pick one favorite spacecraft concept, it would be the INSS MacArthur, an interstellar capable Battlecruiser as described in the novel, The Mote in God's Eye, by Larry Niven and Jerry Pournelle. If I had to pick something from the movies, I would probably say the Nostromo from the first Alien movie.

Question 2: I've noticed you had planetary science guys working on your crew as well as systems engineers. What did the planetary science guy's contribute?

I think you are referring to Artist members of the IAAA that are also planetary scientists. When we go on field trips, they provide great explanations of the local geology as analogues to similar formations we see on other worlds. On a space exploration project, the planetary scientists are, of course, the folks who drive the mission science requirements which ultimately results in designing the science payload for the spacecraft. Planetary scientists working with the systems engineering team is essential to balancing the overall design within the budget and schedule scope of the program.

Question 1: What are some resources we may be able to access as researchers to connect us with artists that could help in conveying and expressing our ideas/research?

Excellent question! The International Association of Astronomical Artists (iaaa.org) has many members who are scientifically oriented and knowledgeable, and capable of rendering a wide range of astronomical and space mission subjects. If you google "scientific illustration," you'll find a number of resources including an excellent Scientific American article about how to find such people.

Question 2: For somebody who is very science minded but artistically incompetent, what are some ways you can think of that could help us explore/develop our artistic and creative sides so we might one day be able to apply that to our profession?

Your own school is an excellent resource for helping you do just that! I had the pleasure of visiting with Ellen Murray Meissinger, who gave me a tour of the ASU School of Art. I saw a few excellent drawing classes in progress that were specifically designed for artistically inexperienced people. The interdisciplinary nature of ASU really encourages you to take advantage of classes outside your immediate discipline. You could jump into painting but learning how to handle paint can be intimidating. I highly recommend you start with an intro to drawing class. A piece of paper and a pencil is about as accessible as you can get. These intro classes teach you how to SEE things as an artist and not simply look. Take one of these classes and you'll certainly have fun as a minimum, and probably learn some skills that you can apply to your profession!

Question 1: Has working recently with children influenced your art or how you view creativity?

I am just starting out in this area so it remains to be seen. But I hope so! The mentoring program does not require that I use art but I fully intend to do so. I plan to create cartoon-style artwork that will hopefully explain technical concepts in a non-intimidating fashion. It will be an interesting challenge which will hopefully nurture my own creativity.

Question 2: How do you stay creative when sometimes your day job requires little Creativity?

Great question! That's a challenge facing many people. You have to make a little time for creativity in any form to avoid going crazy. Keep it simple so you can do it when you have a spare moment. Doodle in your notebook with a pen or pencil! Sketch on your iPad!

Question 1: You have worked on a wide variety of different and interesting projects. Of all of the projects you have worked on, which was the most challenging and/or rewarding and why?

The most rewarding project I've ever worked on is probably NASA's Project Constellation to develop the next-generation crew exploration vehicle (CEV) and lunar surface access module (LSAM) to return humans to the Moon and go beyond. Why? For me, there is nothing more exciting than working on human spacecraft concepts to take us beyond low Earth orbit that have (or at least had) the potential for actually getting built.

I've worked on a number of projects that I considered "challenging" and sometimes that could be in a negative connotation. Various projects were challenging because they were difficult to accomplish within the available time, resources and/or budget. Sometimes the program you're working on has serious problems, negative public perception and/or publicity, team morale problems, etc. Getting your work done in this kind of situation can be quite challenging.

Question 2: You have done art for a wide variety of projects. What was the most interesting or weird project you have worked on and why?

Certainly, one of the weirdest projects I've ever worked on is the DARPA Oblique Flying Wing (OFW). The concept makes technical sense but it just looks like something that can't possibly work! Google it and you'll see what I mean. You'll probably also see a few animations of Northrop Grumman OFW concepts that my visualization team created.

Question 1: When could we expect to see centrifuges on spacecraft?

I don't see any funded projects on the horizon, so unfortunately, it will be a while. But I believe we will do this eventually.

Question 2: How long does it take from a preliminary sketch to get to your final product?

That really depends on a variety of factors, such as the complexity of the project, how much research I have to do, how much modeling needs to be done, how many and what kind of deliverables are required, etc. I've done some projects where I sketched out ideas and delivered a final piece of artwork in a day. Other more elaborate projects take the better part of the year to complete. Typically, my projects take about a month or two to complete.

Question 1: What software/programs do you use to make your designs?

I create 3D models with various software applications such as Modo. My primary software tool for bringing all the elements together and creating finished artwork is Adobe Photoshop.

Question 2: Why is it U.S.C.M and not U.S.M.C., for the abbreviation?

You are referring to the artwork I created for the Aliens movie franchise. The vehicle I designed and rendered was called the Heavy Assault Spacecraft, to be operated by the United States Colonial Marines (USCM), a fictitious interstellar military organization created as part of the Alien backstory. It has nothing to do with the actual United States Marine Corps (USMC). Semper Fi!

Question 1: What would you say would be the most influential aerospace vehicle or event on your decision to start adding art into your career?

I've always added art to my work since I was a child, through my schooling and in my career. This was not driven by any particular aerospace vehicle or event. Though, my earliest recollection of an aerospace event was John Glenn orbiting the earth back in 1962 when I was four years old. I recall making space drawings even back then. Even when I was pursuing a purely technical engineering career, I always enhanced my documentation and briefings with artwork I created. By creating the Engineering Visualization Resource (EVR) at Northrop Grumman in the early 1990s, I just formalized the process.

Question 2: What is the most challenging part of balancing the arts with a career in STEM?

I think the answer to this question depends on an individual's personal journey and career goals. I know engineers and scientists who also happen to be artists, but have chosen to separate the two. For whatever reason, they do not incorporate art in any major way in their professions but choose to separately pursue art as a hobby for recreation and relaxation outside of work. Others like myself work to integrate the arts directly with STEM in their careers. Each of us has to figure out what works and find our own sense of balance in this regard.

Question 1: Where do you draw the line between simplification and spreading misinformation in something like NASA sketch designed for outreach?

Good question. Unfortunately, NASA, ESA, and other Space organizations sometimes use extremely poor artwork to illustrate various online articles and concepts. My organization, the IAAA, is constantly fighting that battle, pointing out to authors and content originators when we see gross inaccuracies in artwork. Beyond that, you bring up a good point. Aerospace concepts are complicated and frequently cannot be easily explained publicly without significant simplification. If the simplifications are not well thought out, they can easily be misinterpreted and lead to the spread of misinformation. The Media is always looking for a simple "sound bite" explanation, which isn't always possible. And the Media is notorious for misinterpreting and/or misrepresenting aerospace information and technology. I think it's up to the outreach communication team to design their graphics carefully and make sure people understand that they are looking at a simplified visualization. Not always easy to do. Also, they should always provide easy access to in-depth resources, allowing those who are interested to seek more detailed information.

Question 2: How can we overcome the notion that art and science are tailored for two distinct groups of people with little overlap?

By pointing out that there actually is a large overlap! Scientists and engineers using artwork in their work, and artists incorporating real science and technology in their work, goes a long way in breaking down such barriers and showing the public that science and art go hand-in-hand.

Question 1: How will visual art influence the engineering breakthroughs of the future?

Art will influence the engineering breakthroughs of the future in precisely the same way it has done so in the past. Art helps to explain and communicate advanced concepts to a broader audience and this is essential to build consensus as we determine the best path forward on any given project. In the 1950s, the artwork created by the great Chesley Bonestell, the father of modern space art, was published in many books and magazines at the time. Working with Wernher von Braun and other aerospace experts, Bonestell's amazing visions made human spaceflight appear real and just around the corner. It also influenced many young people to pursue careers in STEM. This process continues today!

Question 2: Will new technologies (such as VR) reduce the role of traditional art and design in the future?

Artists and Art techniques have always been challenged to evolve as technology has advanced. In some cases, demand for traditional art is reduced because of emerging technologies. For example, there are many astronomy software programs that can create excellent realistic visualizations of planetary surfaces and views of the planets from their various moons, etc. However, artists with skill at composition almost always improve on these visualizations. And there are still many types of artwork and illustrations that cannot be created by simple manipulation of a software application. I see virtual reality as an enhanced method of displaying content and providing a sense of immersion into a computer generated environment. But VR does not create the content in all cases! So, there is still plenty of opportunity to employ traditional art to design and create immersive environments for VR applications.

Question 1: Was there ever a time where you found that it was better to have a non-scientifically accurate scene or drawing?

Certainly. As I briefly described in my presentation, complex subject matter such as the world of electromagnetic sensing and globally networked operational concepts are complicated and difficult to communicate. A bit of artistic license can aid this process considerably. It may be advantageous to enhance the scale of objects, simplify shapes, etc., to improve the ability to communicate this subject matter, even though these enhancements are not strictly accurate.

Question 2: What drawing or representation do you think was the most influential?

That's a difficult question to answer and involves many subjective factors. There have certainly been cases where artwork has added considerably to a project and enhanced public perception. I think the works of aerospace artist Robert McCall for the movie 2001: A Space Odyssey back in the 1960s really captivated the public at the time. Also, NASA maintained a Fine Arts program at one time and employed a number of artists to capture significant moments in Space program history. The NASA Art program yielded some spectacular artwork that greatly influenced the general public as well as the professional aerospace world.

Question 1: Given that your art while at Northrop was designed to inform, did you ever make adjustments for visual impairment? (e.g. color blindness)

That's an interesting question! I was never asked to do this but the idea is intriguing! I have at least one long-term customer who told me years later that he was colorblind. I created many illustrations for this person but they never asked me to make any corrections!

Question 2: What software do you find most useful when designing?

I think a simple pencil and paper is the most useful tool for initial free-form unencumbered brainstorming. I find that's the best way to easily explore and generate a lot of ideas when it comes to shaping any kind of object. There is a variety of excellent 3D software tools available to develop and refine the designs once you have an initial basic configuration. I know that tablets (iPads, etc.) and digital pencils have come a long way and are quite powerful tools. I intend to explore the use of these tools to supplement or potentially even replace pencil sketching.

Question 1: What are your thoughts on “Endurance” spaceship from the movie Interstellar?

Endurance was certainly an interesting design but I have to say that I’m not a fan of this spacecraft concept. I think it was designed more to appear unusual and unlike other movie spacecraft, rather than because of practical considerations. Having a single boom connecting the axial docking module of the vehicle to the outer modular ring appeared to be structurally unsound and made no sense to me. Placing habitat modules right next to the propulsion system and fusion power modules also made no sense to me. The vehicle did not appear to have adequate propellant volume. However, I will say that I am not knowledgeable with regard to whatever trade studies might have been performed to justify this spacecraft configuration. If there is such information available I would be interested in seeing it.

Question 2: How would you design a spacecraft for first manned mission to Mars?

I would design it great! 😊 Probably the most important consideration would be to first determine what type of propulsion system would be used; chemical, nuclear, etc. That has a big influence on the overall configuration of the spacecraft. The other major consideration is to determine the payload. How big of a crew will the vehicle have and how much cargo, including landing craft, will be required? Overall, I would envision a vehicle not all that much different from the Hermes as seen in the movie, The Martian. Though, I would probably not provide nearly as much habitable volume, much to the chagrin of the crew. I would make sure that the onboard food and coffee would be great! 😊

Question 1: How often do your concept sketches turn into real projects?

Very rarely, but it does happen occasionally. I worked on a few programs since they started at the conceptual level. When the actual aircraft finally took to the air, many people on the team commented that it looked exactly like the computer animations my team created years earlier. Hearing that is a good feeling. Generally speaking, hundreds if not thousands of concepts are designed at various levels of detail for every one that becomes an actual vehicle. But that's okay. Advanced concept design and development is a skill set all its own. If we don't do it constantly, we will forget how to do it! Aerospace vehicles are so expensive and take so much time to produce, we must ensure that we get it right before we start cutting any metal. So, it's okay to keep churning out concept sketches in support of aerospace vehicle development projects, even if most of them don't get built.

Question 2: Where does your inspiration come from today?

I draw inspiration from pretty much anything and everything! I generally follow developments in the worlds of science and technology online and if I see something cool, I'll include it in my ever-growing reference library. Sometimes I see an intriguing shape or construct that has nothing directly to do with aerospace, but I can envision it in an aerospace application. I'm also inspired by optimistic people who are able to put their differences with others aside and work constructively on a team. They are willing to compromise and collaborate as they move things forward.

Question 1: Structurally speaking, how different is the Grumman lunar module from its Apollo counterpart?

I'm not sure I understand your question. The Grumman Lunar Module WAS a part of the Apollo program. Perhaps you are referring to the Project Constellation Lunar Surface Access Module (LSAM) concept that I briefly showed during my presentation. Structurally speaking, such a vehicle would not be all that different from the original Grumman Apollo LM. But it would be larger in scale and would take advantage of newer advanced materials.

Question 2: Are there any spacecraft designs that have been portrayed in scifi movies that could be feasible to build in the near future?

The Hermes as seen in the movie, The Martian, appears to be a reasonable overall design for a near future interplanetary spacecraft. Though as I mentioned in my talk, it probably would not have nearly as much habitable volume as depicted in the film.

Question 1: How significant would you say it is in your field/area of work to have connections to important people versus ability? Clearly both are important, but would you consider either connections and interpersonal skills, or actual artistic and scientific ability to be more necessary to find success?

In any human endeavor, having personal connections will always be an important career factor. Looking back on my career and all the various businesses and organizations that I have been exposed to, I would say that you really need to have both interpersonal skills and professional ability. I would say that you should not look at it as one attribute being more necessary than the other. Each person needs to find the best balance of these attributes based on their own personal style and situation. If you are the absolute best in your field but have a reputation for being difficult to work with, you certainly won't advance your career as well as someone who has good interpersonal skills.

Question 2: Do you believe that entertainment should strive to achieve more scientifically accurate story components, or is there some gain in entertainment value that's worth suspending realistic design elements?

Heck yes! I think entertainment media of any kind would always benefit from scientific accuracy. Real science and technology are generally cooler and more intriguing than the fake stuff the entertainment industry typically comes up with. If the writers understand the implications of real science and physics, they can weave that into their storytelling and come up with some truly compelling stuff! I don't think it's ever a case of the entertainment industry actually "suspending realistic design elements." In my experience, they simply don't know any better and frequently believe they are coming up with accurate depictions when in fact, they are not.

Question 1: What type of friction did you experience from fellow engineers and management when you tried to introduce art in a highly technical field?

That's a good question. I certainly did experience some friction when I first tried to set up my engineering visualization group at Northrop, more so from management than my fellow engineers. Of course, I was asking management for the money, so it was perfectly understandable if they were somewhat resistant and skeptical! Not everyone saw the value in what I was trying to do and thought it was a waste of time and money, until I demonstrated it for them on a few projects.

Question 2: Does industry value the power of science visualization in the RFP and development process?

That's another good question. I would say yes, Industry certainly does value the power of scientific visualization in general, and as applied to the RFP process in particular. The problem here is one of maintaining fairness and managing cost in a competitive environment. Many program customers such as NASA and the Department of Defense frequently do not want proposals to contain extensive visualizations. The thinking is that companies that have greater financial resources might put a great deal of effort into creating elaborate glitzy media products that visually and subjectively overshadow their competitors. Other companies may have an excellent technical proposal that meets the requirements at lower cost, but they simply don't look as good! So, I have found that RFP language is usually very careful with regard to what kinds of visualizations are appropriate for and allowable in proposals.

Question 1: What is your greatest artistic attempt to capture futuristic workspaces that was eventually built?

I don't personally specialize in facility and workspace design but I have created a number of such illustrations. At Northrop Grumman, my engineering visualization team did create a number of illustrations and animated walk-throughs of proposed laboratories and control centers. Sometimes we did have significant authority to influence the facility design. Other times we were illustrating what the architects and/or lab managers roughly envisioned. A few of these facilities were actually built and looked quite a bit like our visualizations. That is a satisfying feeling!

Question 2: You mention your interest in centrifuge production, how are you currently promoting the development of this product for human use in space?

I'm certainly not involved in any actual lobbying campaign with NASA! The best way I can promote any particular design feature or concept is to incorporate it into the spacecraft designs that I'm currently developing. These will be used for my own future outreach projects and promotions.

Question 1: What/ Where do you draw inspiration from for your designs and how do you balance being artistic with being scientifically accurate?

I draw inspiration from pretty much anything and everything! I generally follow developments in the worlds of science and technology online and if I see something cool, I'll include it in my ever-growing reference library. Sometimes I see an intriguing shape or construct that has nothing directly to do with aerospace, but I can envision it in an aerospace application. I love the early stages of the project when I am just freeform sketching various shapes of aerospace vehicles for a specific mission type. When I start to come up with a few directions that look promising, I start to think about incorporating the subsystem features I know will be required. The balancing of the technical requirements with aesthetic considerations is a sort of free flowing non-rigorous process that feels very natural to me. Feel the Force flowing within you!

Question 2: Do you have plans to write your own sci-fi illustrated novel? That'd be super cool.

I've always dreamed about writing hard science fiction short stories and perhaps a novel or graphic novel. I do have some story ideas I've been bouncing around in my head for years. It's on my long-range to do list! ☺ I like to write but for me, it doesn't flow as naturally as visual artistic expression. If I did a graphic novel, I would love to design and storyboard the whole thing but I'm not very good at rendering human figures. I would probably team up with one or several artists to create the characters and do the final artwork. That would be fun!

Question 1: Thank you for the wonderful talk. My question is, what kind of aircraft/spacecraft would you develop, provided you have all the resources to develop that craft?

You are quite welcome and great question! I find myself intrigued by the idea of the minimalist pure spacecraft for a single person, designed for operations either on the surfaces of the various small moons and asteroids of the solar system. This is the so-called “single-ship.” If you were an astro-miner/pro prospector/geologist, etc., at some point in the future, what would the minimal affordable vehicle look like to safely take you where you needed to go? How would it need to be configured to keep you alive, healthy, and reasonably comfortable for a long enough period of time for you to conduct your research and/or business? As soon as you add atmospheric requirements and a fairly high gravity field, that complicates the design. So, I’m specifically talking about vehicles designed to operate in vacuum or near-vacuum, as well as zero gravity or micro/low-gravity environments. At some point in the future, I hope that our solar system is swarming with adventurous human beings operating such craft!

Question 2: In your talk you also mentioned about Environmentally Responsible Aircraft (ERA). Do you think if it's possible to convert present aircrafts into ERA? What kind of obstacles there might be to convert normal aircraft to ERA?

When NASA runs a project like ERA, one of the goals is to explore and develop design ideas and technologies that can indeed be incorporated into the current global fleet of aircraft. Obviously it would be difficult to drastically alter the shape of current aircraft that are very carefully designed for a specific flight environment. You’d be better off designing and developing a new aircraft from scratch, which of course is quite costly. But, there are incremental improvements in things like propulsion efficiency and noise reduction that can be incorporated. This sort of thing is happening all the time and a program like ERA adds to that body of knowledge.

Question 1: Are you ever disappointed when a customer requests you sacrifice technical accuracy in your designs?

Ha ha, it depends on how much they're paying me! ☺ I'm pretty flexible and I like to give a customer what they want. But sure, I always try to steer them to make the design as credible as possible. There were certainly some projects where I was disappointed in my customer's choices, but that's okay. I do my best to express my desire to blend technical accuracy and aesthetic considerations in my own design projects.

Question 2: Do you now or did you in the past ever find it difficult to balance your artistic and engineering interests?

Each project and organization you wind up working with presents its own challenges. By successfully creating and operating my engineering visualization group, I solved the art/engineering balancing problem by "institutionalizing" the process. That's what we did and people paid us to do it! And yes, many times it was and still is difficult. That's usually not because of any conceptual challenge, but because of budget and schedule constraints. You want it when??

Question 1: What is the hardest concept you have tried to depict in one of your visualizations?

Probably the hardest concept that I have tried to depict visually is the idea of cost reduction. As you might imagine, cost savings and/or reductions are a popular selling point on large aerospace program developments (assuming you believe them). Program managers would frequently ask my team to visually depict these cost reductions in some way. It's more of a graphic challenge rather than a design challenge. You typically show some kind of downward trending graph, perhaps incorporating \$ symbols, dollar bills, etc. It's hard to visually communicate cost reduction without resorting to these visual clichés.

Question 2: For new mission and architecture concepts, it seems like the visualization team and the early artist concepts have a big influence on the projected budget of the overall project. Do you consider budgets when developing your artist concepts?

In my experience, the visualization team essentially has no influence on the projected budget of aerospace projects. On the other hand, in the world of Hollywood and video game development, the end product is a visualization. So, in that case, the early concepts and designs do influence the overall budget of the project. If you intend to be a working artist/illustrator/visualizer, you MUST consider budgets as well as schedules. You must learn to figure out how to realistically budget and schedule your own work so that you can develop credible proposals. It's no different from being any other kind of service provider. If you hire someone to do some work for you, you would probably be very unhappy if, after they start working, they tell you that the project will cost twice as much and take twice as long as originally projected. The process of creating art and designing concepts is no different.

Question 1: Can we or is it possible to depend on imaginary sometimes when the work is about space?

Yes, I would say imagination is essential to everything. This is especially true when envisioning space-related stuff that doesn't exist yet. My goal is to create design ideas that are compelling and believable so that and people will conclude "yeah, we can do that!"

Question 2: What needed or comes on your mind to have a perfect well studied design?

I'm not rigorous when it comes to the notion of being "perfect." As an engineer, I know that perfect is the enemy of good enough! ☺ I just keep working my design concepts until my customer is happy with them or I run out of budget. Hopefully I achieve the former before the later!

Question 1: How many iterations of concept art do you typically go through before you reach your final design?

That really depends on a variety of factors, such as the complexity of the project, how much research I have to do, etc. It also depends on the customer. I work for a number of people I have come to know well. They are good at explaining what they want and I already understand their expectations based on previous projects. In that case, I can usually zero in on a design fairly quickly. On the other hand, I've worked with some customers who want something extremely complicated and difficult to envision, and sometimes it's quite a challenge to zero in on a workable design. Some customers are good at telling you what they don't want rather than what they want, and that can lead to many design iterations as well.

Question 2: What principles do you apply when you have to explain a complicated scientific concept or engineering plan through a purely visual medium, while also making the image visually interesting?

My colloquium talk it is a pretty good example of how I go about doing this. I'll let you be the judge of how well I did. I don't like to have many word slides and I don't have a rigorous script. I talk to the pictures and stumble along and hopefully communicate the essence of what I'm doing!

Question 1: Have you ever considered or already created some cartoon stories based on your own work?

I've certainly drawn a few individual cartoons but never a "cartoon story." I've considered writing and illustrating a graphic novel. I do have some story ideas I've been bouncing around in my head for years. I like to write but for me, it doesn't flow as naturally as visual artistic expression. If I did a graphic novel, I would love to design and storyboard the whole thing but I'm not very good at rendering human figures. I would probably team up with one or several artists to create the characters and do the final artwork. That would be fun!

Question 2: What is your opinion about the potential negative effects when considering the stories in the movie "Interstellar" in 2014?

Interstellar was interesting but I have to say that I'm not a big fan of this movie. I'm not sure exactly what you mean by "potential negative effects." At least Interstellar showed that despite the environmental problems that humanity wrought upon the Earth, we still survived. We maintained a spacefaring capability and managed to establish a permanent human presence off the Earth. I'd say that's a positive effect! If you mean "potential negative effects" brought about by things like time dilation, then yes, that has been explored in numerous science fiction stories. I think that when we are able to achieve human space travel fast enough to experience time dilation effects, it will have profound implications for human life, both pro and con.